



US006693774B2

(12) **United States Patent**
Watanabe et al.

(10) **Patent No.:** **US 6,693,774 B2**
(45) **Date of Patent:** **Feb. 17, 2004**

(54) **MAGNETORESISTIVE SENSOR AND
MAGNETIC STORAGE APPARATUS**

(75) Inventors: **Katsuro Watanabe**, Odawara (JP);
Hiromasa Takahashi, Hachioji (JP);
Nobuo Yoshida, Odawara (JP); **Takashi**
Kawabe, Hitachi (JP); **Kazuhiro**
Nakamoto, Tokyo (JP)

(73) Assignee: **Hitachi, Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 246 days.

(21) Appl. No.: **09/803,032**

(22) Filed: **Mar. 12, 2001**

(65) **Prior Publication Data**

US 2001/0028538 A1 Oct. 11, 2001

(30) **Foreign Application Priority Data**

Mar. 13, 2000 (JP) 2000-073925

(51) **Int. Cl.**⁷ **G11B 5/127**; G11B 5/39

(52) **U.S. Cl.** **360/319**

(58) **Field of Search** 360/319, 320,
360/317, 324, 324.1, 324.2, 323, 313, 110

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,206,590 A 4/1993 Dieny et al. 324/252

5,568,335 A * 10/1996 Fontana et al. 360/320
5,936,810 A 8/1999 Nakamoto et al. 360/324.1
6,292,334 B1 * 9/2001 Koike et al. 360/319
6,452,761 B1 * 9/2002 Carey et al. 360/320
2002/0015267 A1 * 2/2002 Sato 360/320
2002/0027753 A1 * 3/2002 Ishiwata et al. 360/324.2

FOREIGN PATENT DOCUMENTS

JP 4-358310 12/1992
JP 5-266437 10/1993
JP 9-282618 10/1997

* cited by examiner

Primary Examiner—Julie Anne Watko

(74) *Attorney, Agent, or Firm*—Antonelli, Terry, Stout &
Kraus, LLP

(57) **ABSTRACT**

A magnetoresistive sensor which, despite a narrow reproducing shield gap, affords high resolution and high reproducing output because of its structure and is able to minimize the amount of sense current leaking into the shield layer through the gap layer. A magnetic storage apparatus suitable for high-density recording is provided with a magnetic head having said magnetoresistive sensor. The structure is characterized in that at least either of the lower shield layer or upper shield layer is partly or entirely a magnetic layer which is a composite film composed of ferromagnetic metal and oxide, and an insulation protective film is arranged between the electrode film or longitudinal bias film and the magnetic film which is a composite film composed of ferromagnetic metal and oxide.

14 Claims, 12 Drawing Sheets

